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Chen

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(54) **METHOD FOR MANUFACTURING ELECTRODE**

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H01M 4/36 (2006.01)
H01M 4/139 (2010.01)

(52) **U.S. Cl.**
CPC ***H01M 4/0404*** (2013.01); ***H01M 4/0435*** (2013.01); ***H01M 4/0471*** (2013.01); ***H01M 4/139*** (2013.01); ***H01M 4/366*** (2013.01)

(58) **Field of Classification Search**
CPC H01M 4/0404
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0063071	A1	3/2006	Yasuda et al.	
2009/0029251	A1*	1/2009	Baba	H01M 2/1016 429/209
2010/0203308	A1	8/2010	Mennig et al.	
2011/0068001	A1*	3/2011	Affinito	H01M 4/13 204/242
2014/0308576	A1*	10/2014	Gaben	C25D 13/02 429/185
2017/0110760	A1*	4/2017	Hatta	H01M 10/056
2018/0048040	A1*	2/2018	Liu	H01G 11/08

FOREIGN PATENT DOCUMENTS

CN	103718346	4/2014
CN	103769086	5/2014
JP	2005353384	12/2005
TW	200531331	9/2005
TW	200606282	2/2006

* cited by examiner

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(57) **ABSTRACT**

A method for manufacturing an electrode is provided. A composite including a carrier layer and a collector layer disposed thereon is provided. The collector layer has a first surface and an opposite second surface, and the first surface of the collector layer faces to the carrier layer. A first coating process is performed to coat first electrode material on the second surface of the collector layer. A first curing process is performed to dry the first electrode material. The carrier layer is removed after the first electrode material is dried to expose the first surface of the collector layer. A second coating process is performed to coat a second electrode material on the first surface of the collector layer. A material of the second electrode material is same with that of the first electrode material. A second curing process is performed to dry the second electrode material.

8 Claims, 6 Drawing Sheets

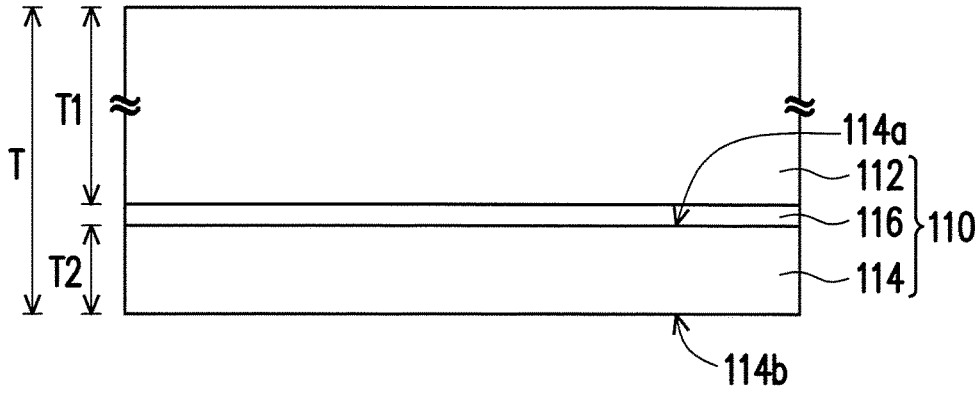

FIG. 1A

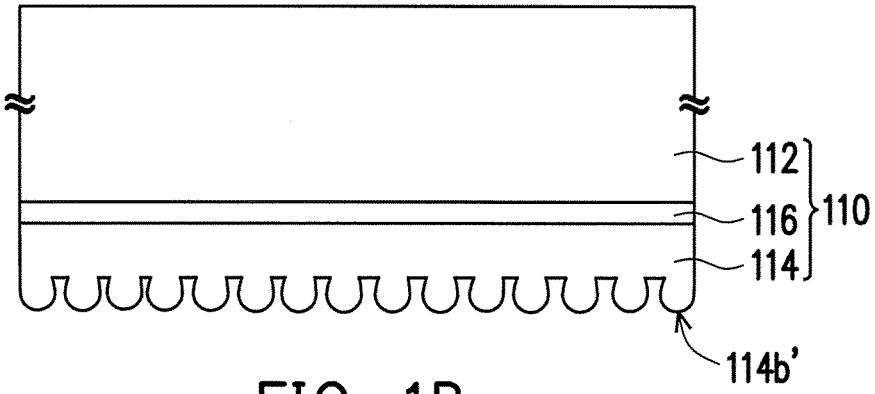

FIG. 1B

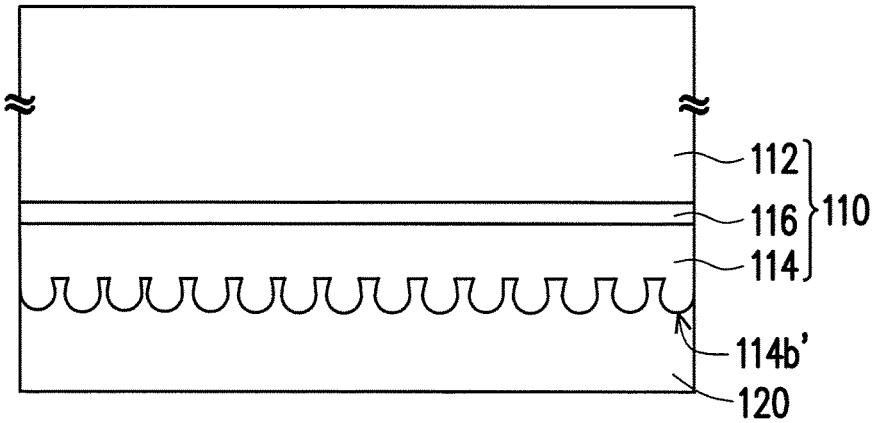

FIG. 1C

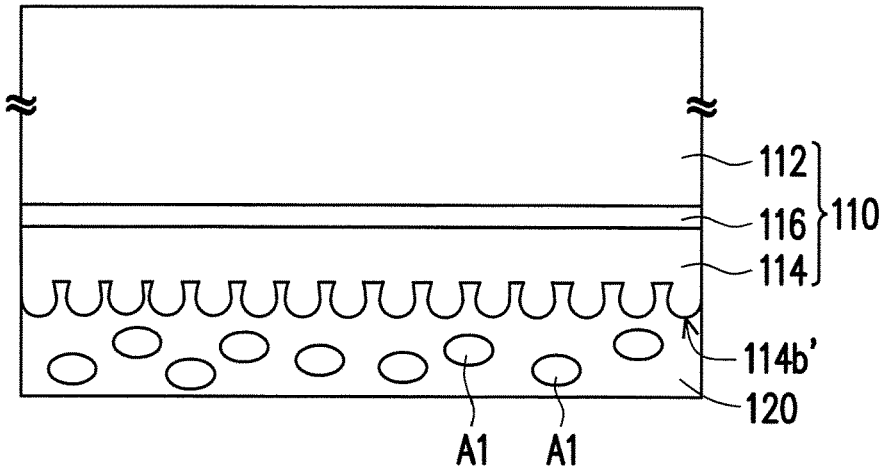

FIG. 1D

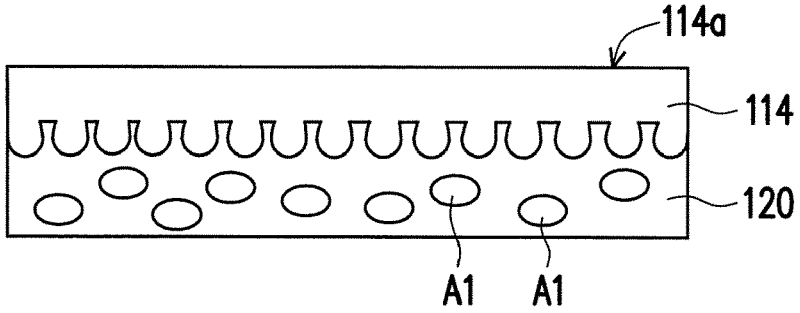

FIG. 1E

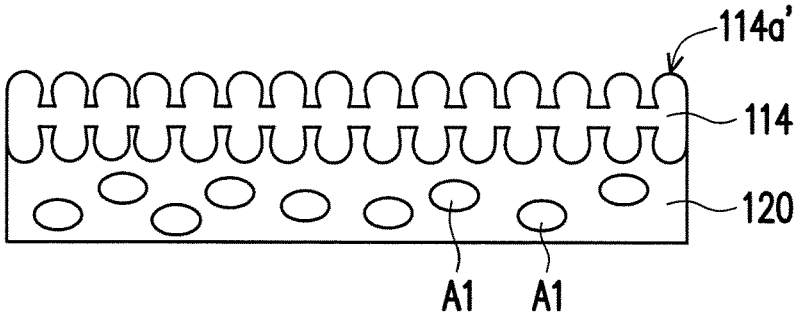

FIG. 1F

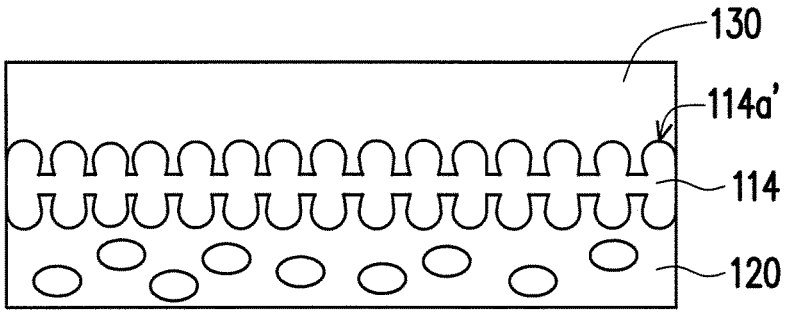

FIG. 1G

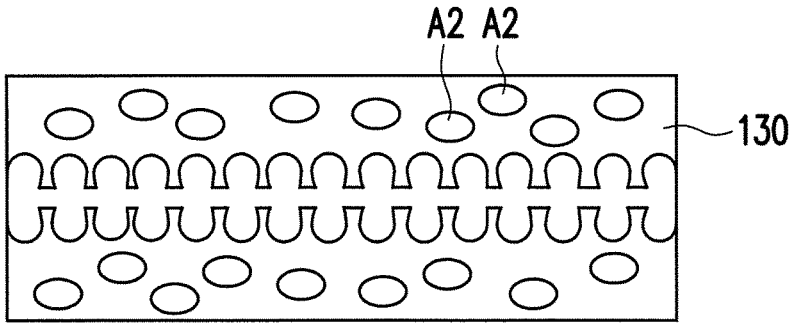

FIG. 1H

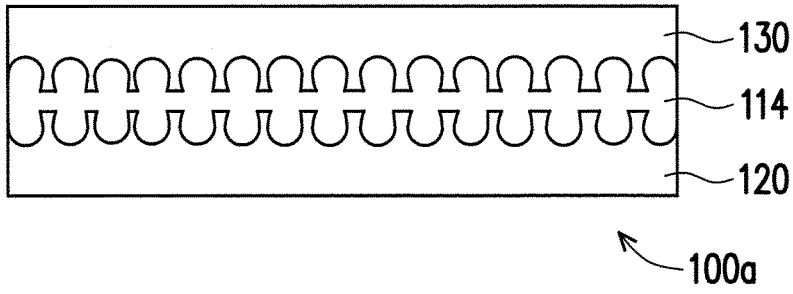

FIG. 1I

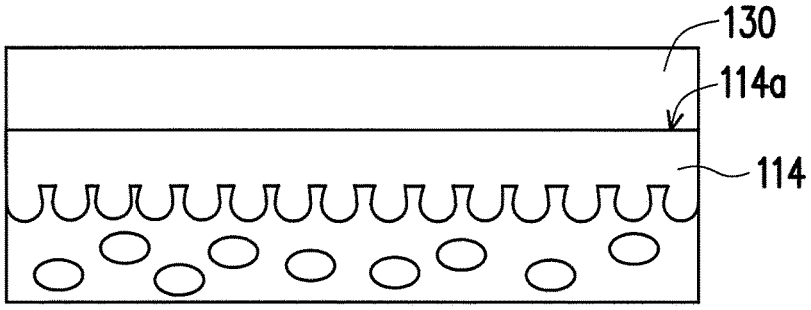

FIG. 2A

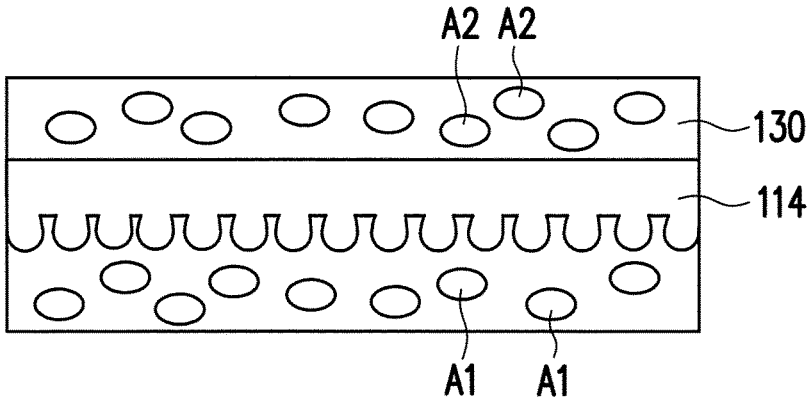

FIG. 2B

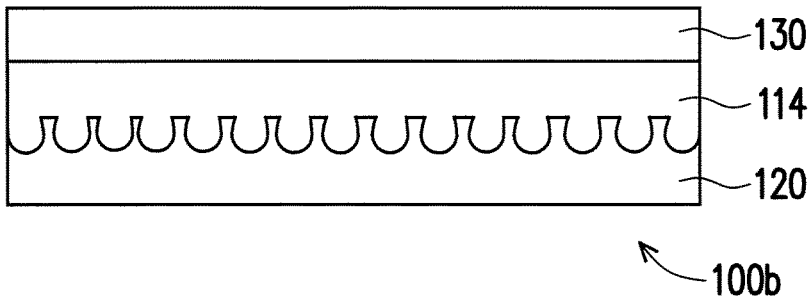

FIG. 2C

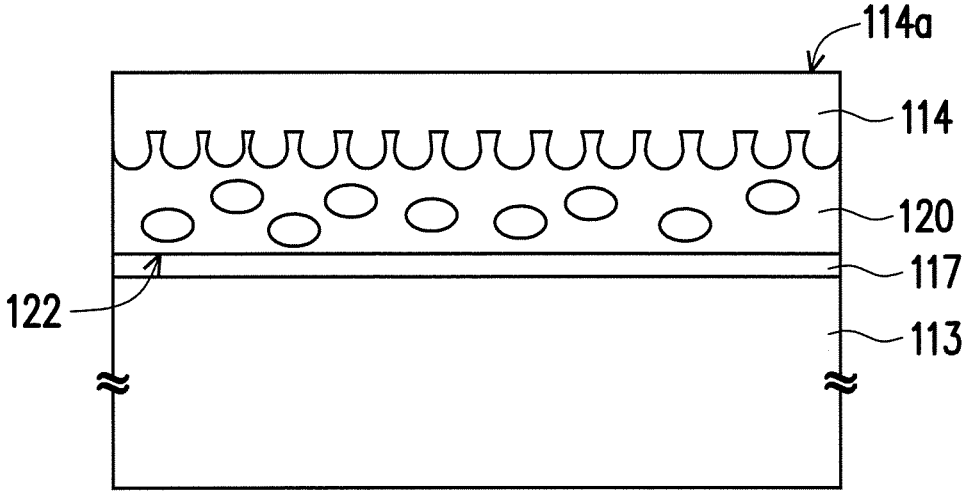

FIG. 3A

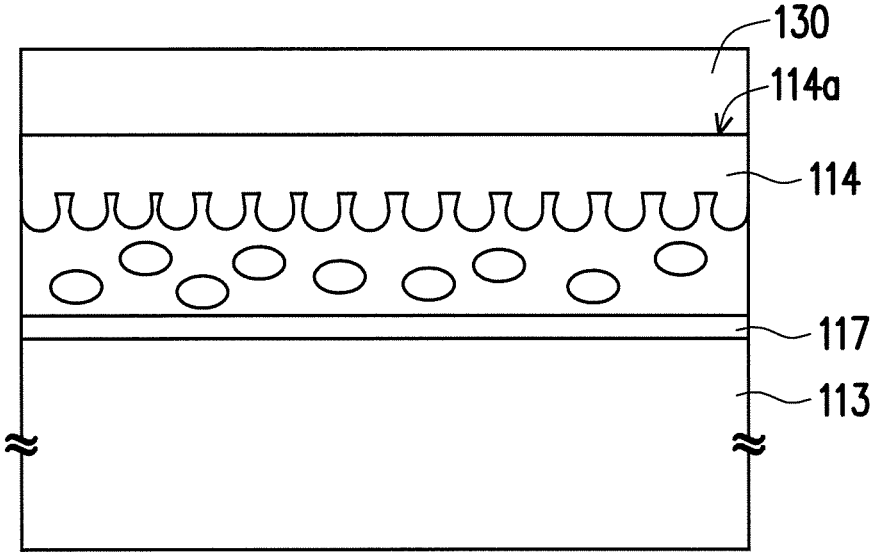

FIG. 3B

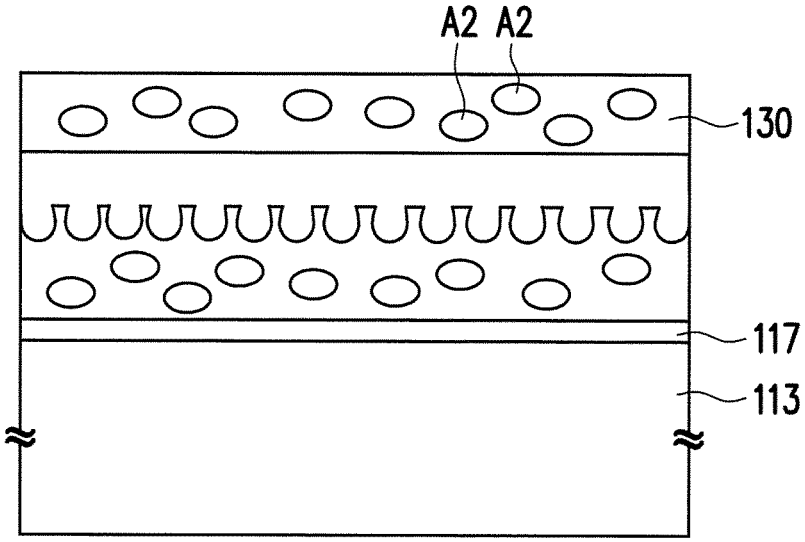

FIG. 3C

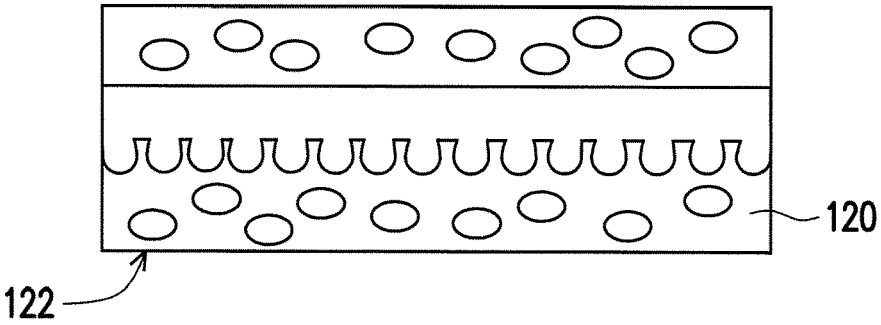

FIG. 3D

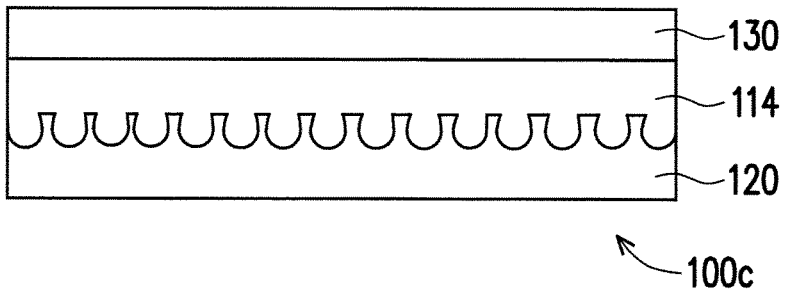

FIG. 3E

METHOD FOR MANUFACTURING ELECTRODE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of TW application serial No. 105106312, filed on Mar. 2, 2016. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of specification.

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a method for manufacturing an electric component and, more particularly, to a method for manufacturing an electrode.

Description of the Related Art

Generally, a volume energy density of a battery is increased by reducing the thickness of an anode/cathode collector layer. However, when the collector layer is thin, the tensile strength is week, and then the collector layer is easily cracked under the same conditions in the slurry coating process. Moreover, the thin collector layer may not meet the requirement for the process equipment.

BRIEF SUMMARY OF THE INVENTION

According to one aspect of the disclosure, a method for manufacturing an electrode, comprises: providing a composite material including a carrier layer and a collector layer disposed on the carrier layer, wherein the collector layer includes a first surface and a second surface opposite to each other, and the first surface of the collector layer faces to the carrier layer; performing a first coating process to coat a first electrode material on the second surface of the collector layer; performing a first curing process to dry the first electrode material; removing the carrier layer to expose the first surface of the collector layer after the first electrode material is dried; performing a second coating process to coat a second electrode material on the first surface of the collector layer, wherein a material of the second electrode material is same with the material of the first electrode material; and performing a second curing process to dry the second electrode material.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the invention will become better understood with regard to the following embodiments and accompanying drawings.

FIG. **1**A to FIG. **1**I are cross-section diagrams showing a method for manufacturing an electrode in a first embodiment;

FIG. **2**A to FIG. **2**C are cross-section diagrams showing partial steps of a method for manufacturing an electrode in a second embodiment; and

FIG. **3**A to FIG. **3**E are cross-section diagrams showing partial steps of a method for manufacturing an electrode in a third embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

FIG. **1**A to FIG. **1**I are cross-section diagrams showing a method for manufacturing an electrode in a first embodiment. Please refer to FIG. **1**A, in the embodiment, a composite material **110** is provided. The composite material **110** includes a carrier layer **112** and a collector layer **114** disposed on the carrier layer **112**. The collector layer **114** includes a first surface **114***a* and a second surface **114***b* opposite to each other, and the first surface **114***a* of the collector layer **114** faces to the carrier layer **112**.

In detail, in the embodiment, a thickness T**1** of the carrier layer **112** is larger than a thickness T**2** of the collector layer **114**. In an embodiment, the thickness T**1** of the carrier layer **112** is 6 micrometer (μm) to 200 μm, and the thickness T**2** of the collector layer **114** is 1 μm to 6 μm, which are not limited herein. In the embodiment, the composite material **110** further includes a release layer **116** disposed between the carrier layer **112** and the collector layer **114** to facilitate release the carrier layer **112** and the collector layer **114** thereafter. In an embodiment, the material of the carrier layer **112** is a metal foil (such as copper, aluminum, stainless steel) or a polymer (such as polyimides (PI), polymethyl methacrylate (PMMA), polypropylene (PP), polycarbonate (PC), polyethylene (PE), polyethylene terephthalate (PET), polyvinyl chloride (PVC)) or a combination thereof, which is not limited herein. The material of the collector layer **114** is a composite metal foil, such as one or a combination selected from the group consisting: copper foil, aluminum foil, stainless steel foil. The release layer **116** is an adhesive for attaching the carrier layer **112** and the collector layer **114** and the material of the release layer **116** is polypropylene and/or polyethylene, which is not limited herein.

Please refer to FIG. **1**B, a first roughening process is performed to roughen the second surface **114***b* of the collector layer **114** to form a second surface **114***b*', for increasing a contact area between the electrode material and the collector layer **114**. The first roughening process is an optional step, which can be selectively to be performed. In an embodiment, a ten-point average roughness (Rz) of the second surface **114***b*' is 0.1 μm to 4 μm, and the first roughening process is a chemical roughening process or a physical roughening process. For example, in the chemical roughening process, the second surface **114***b* of the collector layer **114** is roughened via a chemical agent; in the physical roughening process, the second surface **114***b* of the collector layer **114** is grinded via an abrasive, or the plasma bombardment or the sanding blast is performed to the second surface **114***b* of the collector layer **114**.

Please refer to FIG. **1**C, a first coating process is performed, a first electrode material **120** is coated on the second surface **114***b*' of the collector layer **114**. In an embodiment, the first electrode material **120** is an anode material or a cathode material, the anode material is one or a combination selected from the group consisting: lithium cobalt oxide, lithium cobalt nickel manganese oxide, lithium nickel and titanium oxide, lithium manganese oxide, lithium iron phosphate, and lithium nickel manganese oxide; the cathode material is one or a combination selected from the group consisting: graphite, silicon carbide, silicon oxide, and tin oxide, which is not limited herein.

Please refer to FIG. **1**D, a first curing process is performed to dry the first electrode material **120**. In the embodiment, the time for the first curing process is 30 min to 120 min, and the temperature for the first curing process is 90° C. to 150° C. Since the first electrode material **120** is in a fluid form, at least a first air gap A**1** is generated in the first electrode material **120** when the first curing process is performed.

Please refer to FIG. **1**D and FIG. **1**E, the carrier layer **112** is removed to expose the first surface **114***a* of the collector layer **114** after the first electrode material **120** is dried. In an

embodiment, the carrier layer **112** and the release layer **116** thereon are removed by removing of the release layer **116** which is located between the carrier layer **112** and the collector layer **114**.

Please refer to FIG. **1**E and FIG. **1**F, a second roughening process is performed to roughen the first surface **114***a* of the collector layer **114** to form a first surface **114***a*', for increasing a contact area between the electrode material and the collector layer **114**. The second roughening process is an optional step, which is selectively to be performed. In an embodiment, a ten-point average roughness (Rz) of the first surface **114***a*' is 0.1 μm to 4 μm, and the second roughening process is a chemical roughening process or a physical roughening process. For example, in the chemical roughening process, the first surface **114***a* of the collector layer **114** is roughened via a chemical agent; in the physical roughening process, the first surface **114***a* of the collector layer **114** is grinded via an abrasive, or the plasma bombardment or the sanding blast is performed to the first surface **114***a* of the collector layer **114**.

Please refer to FIG. **1**G, a second coating process is performed, and then a second electrode material **130** is coated on the first surface **114***a*' of the collector layer **114**. The material of the second electrode material **130** is same with that of the first electrode material **120**. In an embodiment, the second electrode material **130** is an anode material or a cathode material, the anode material is one or a combination selected from the group consisting: lithium cobalt oxide, lithium cobalt nickel manganese oxide, lithium nickel and titanium oxide, lithium manganese oxide, lithium iron phosphate, and lithium nickel manganese oxide; the cathode material is one or a combination selected from the group consisting: graphite, silicon carbide, silicon oxide, and tin oxide, which is not limited herein.

Please refer to FIG. **1**H, a second curing process is performed to dry the second electrode material **130**. The time for the second curing process is 30 min to 120 min, and the temperature for the second curing process is 90° C. to 150° C. Since the second electrode material **130** is in a fluid form, at least a second air gap A**2** is formed in the second electrode material **130** when the second curing process is performed.

Please refer to FIG. **1**H and FIG. **1**I, the dried first electrode material **120** and the dried second electrode material **130** are rolled to squeeze out the first air gap A**1** and the second air gap A**2**, and then the conducting efficiency of the electrode **100***a* is improved. Then, the electrode **100***a* is formed.

In the embodiment, the carrier layer **112** is used as a supporting layer for the collector layer **114** in the manufacture of the electrode **100***a*. Therefore, the collector layer **114** has a good tensile strength when the first coating process and the first curing process are performed. In addition, after the first electrode material **120** is dried, the carrier layer **112** is removed. Thus, the formed electrode **100***a* has no the carrier layer **112**, and then the thickness of the electrode **100***a* becomes thinner. Furthermore, since the electrode **100***a* is thinner, the battery (not shown) formed by stacking of the electrodes **100***a* has a higher volume energy density, and the service life is increased by 5%~30%. In addition, in the embodiment, a roughening process is performed to the first surface **114***a* and the second surface **114***b* of the collector layer **114**, the roughness of the first surface **114***a*' and the second surface **114***b*' is improved, and thus the contact area between the first electrode material **120**, the second electrode material **130** with the collector layer **114** is increased, and the charging/discharging power value of the battery is improved.

FIG. **2**A to FIG. **2**C are cross-section diagrams showing partial steps of a method for manufacturing an electrode in a second embodiment. Please refer to FIG. **2**C, in the embodiment, the method for manufacturing the electrode **100***b* is similar to the method for manufacturing the electrode **100***a* in FIG. **1**A to FIG. **1**I, and the difference between the two embodiments is the steps after the step of removing the carrier layer **112** to expose the first surface **114***a* of the collector layer **114** in FIG. **1**E, and the same steps are not described again.

Please refer to FIG. **2**A, a second coating process is performed to coat a second electrode material **130** on the first surface **114***a* of the collector layer **114**. In the embodiment, after the step in FIG. **1**E, the roughening process is not performed to the first surface **114***a* of the collector layer **114**.

Please refer to FIG. **2**B, a second curing process is performed to dry the second electrode material **130**. The time for the second curing process is 30 min to 120 min, and the temperature for the second curing process is 90° C. to 150° C. Since the second electrode material **130** is in a fluid form, at least a second air gap A**2** is generated in the second electrode material **130** when the second curing process is performed.

Please refer to FIG. **2**B and FIG. **2**C, the dried first electrode material **120** and the dried second electrode material **130** are rolled to squeeze out the first air gap A**1** and the second air gap A**2**, and then the conducting efficiency of the electrode **100***b* is improved. Then, the electrode **100***b* is formed.

FIG. **3**A to FIG. **3**E are cross-section diagrams showing partial steps of a method for manufacturing an electrode in a third embodiment. Please refer to FIG. **3**A, in the embodiment, the method for manufacturing the electrode **100***c* is similar to the method for manufacturing the electrode **100***b*, and the difference therebetween is that: after the step in FIG. **1**E (that is the step of removing the carrier layer **112** to expose the first surface **114***a* of the collector layer **114**), the carrier layer **113** and the release layer **117** are provided to increase the tensile strength. The carrier layer **113** is configured on the surface **122** of the dried first electrode material **120** far away from the collector layer **114** via the release layer **117**. The carrier layer **113** is used as a supporting layer in the subsequent of the second coating process, and the carrier layer **113** can also increase the tensile strength of the collector layer **114** and the first electrode material **120**. The release layer **117** can be regard as the adhesive between the carrier layer **113** and the first electrode material **120**. The material of the carrier layer **113** is a metal foil (such as copper, aluminum, stainless steel) or a polymer (such as PI, PMMA, PP, PC, PE, PET, PVC) or a combination thereof, which is not limited herein. The thickness of the carrier layer **113** is 6 μm to 200 μm, which is not limited herein. The step in FIG. **3**A is an optional step, which can be selectively to be performed.

Please refer to FIG. **3**B, a second coating process is performed, and then a second electrode material **130** is coated on the first surface **114***a* of the collector layer **114**. In the embodiment, the roughening process is not performed to the first surface **114***a* of the collector layer **114**.

Please refer to FIG. **3**C, a second curing process is performed to dry the second electrode material **130**. The time for the second curing process is 30 min to 120 min, and the temperature for the second curing process is 90° C. to 150° C. Since the second electrode material **130** is in a fluid

form, at least a second air gap A2 is generated in the second electrode material **130** when the second curing process is performed.

Please refer to FIG. **3**C and FIG. **3**D, the carrier layer **113** and the release layer **117** are removed to expose the surface **122** of the first electrode material **120**. The release layer **117** between the carrier layer **113** and the first electrode material **120** is peeled to remove the release layer **117** and the carrier layer **113**.

Please refer to FIG. **3**E, the dried first electrode material **120** and the dried second electrode material **130** are rolled to squeeze out the first air gap A1 and the second air gap A2 to increase the conducting efficiency of the electrode **100***c*. Then, the electrode **100***c* is formed.

In sum, in the method for manufacturing the electrode in embodiments, the collector layer is disposed on the carrier layer, and then the carrier layer is regarded as a supporting layer for the collector layer, so as to improve the tensile strength of the collector layer. After the first electrode material is dried, the carrier layer is removed. To increase the tensile strength, the carrier layer is attached to serve as a supporting layer for the second coating process before the second electrode material is coated. After the second electrode material is dried, the carrier layer is removed, and then the formed electrode has no the carrier layer, thus, the electrode is thinner and the battery formed by stacking the electrode **100***a* has a higher volume energy density.

Although the invention has been disclosed with reference to certain preferred embodiments thereof, the disclosure is not for limiting the scope. Persons having ordinary skill in the art may make various modifications and changes without departing from the scope of the invention. Therefore, the scope of the appended claims should not be limited to the description of the preferred embodiments described above.

What is claimed is:

1. A method for manufacturing an electrode, comprising:

providing a composite material including a carrier layer and a collector layer disposed on the carrier layer, wherein the collector layer includes a first surface and a second surface opposite to each other, and the first surface of the collector layer faces to the carrier layer;

performing a first coating process to coat a first electrode material on the second surface of the collector layer;

performing a first curing process to dry the first electrode material;

removing the carrier layer to expose the first surface of the collector layer after the first electrode material is dried;

performing a second coating process to coat a second electrode material on the first surface of the collector layer, wherein a material of the second electrode material is same with the material of the first electrode material;

performing a second curing process to dry the second electrode material;

providing another carrier layer on a surface of the dried first electrode material far away from the collector layer after the carrier layer is removed and before the second coating process is performed, wherein the another carrier layer is configured on the surface of the collector layer via a release layer; and

removing the another carrier layer and the release layer to expose the surface of the first electrode material after the second electrode material is dried.

2. The method for manufacturing the electrode according to claim **1**, further comprising:

performing a first roughening process to roughen the second surface of the collector layer after the composite material is provided and before the first coating process is performed.

3. The method for manufacturing the electrode according to claim **2**, further comprising:

performing a second roughening process to roughen the first surface of the collector layer after the carrier layer is removed and before the second coating process is performed.

4. The method for manufacturing the electrode according to claim **1**, wherein a thickness of the carrier layer is 6 μm to 200 μm.

5. The method for manufacturing the electrode according to claim **1**, wherein the first electrode material is an anode material or a cathode material.

6. The method for manufacturing the electrode according to claim **1**, wherein the composite material further includes a release layer configured between the carrier layer and the collector layer.

7. The method for manufacturing the electrode according to claim **6**, wherein a material of the release layer is polypropylene and/or polyethylene.

8. The method for manufacturing the electrode according to claim **1**, further comprising:

when the first curing process is performed, a first air gap is generated in the first electrode material;

when the second curing process is performed, a second air gap is generated in the second electrode material; and

rolling the dried first electrode material and the dried second electrode material to squeeze out the first air gap and the second air gap.

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